Are You a Hypoxia Expert?

By Cdr. Kevin E. Brooks, MD, MPH

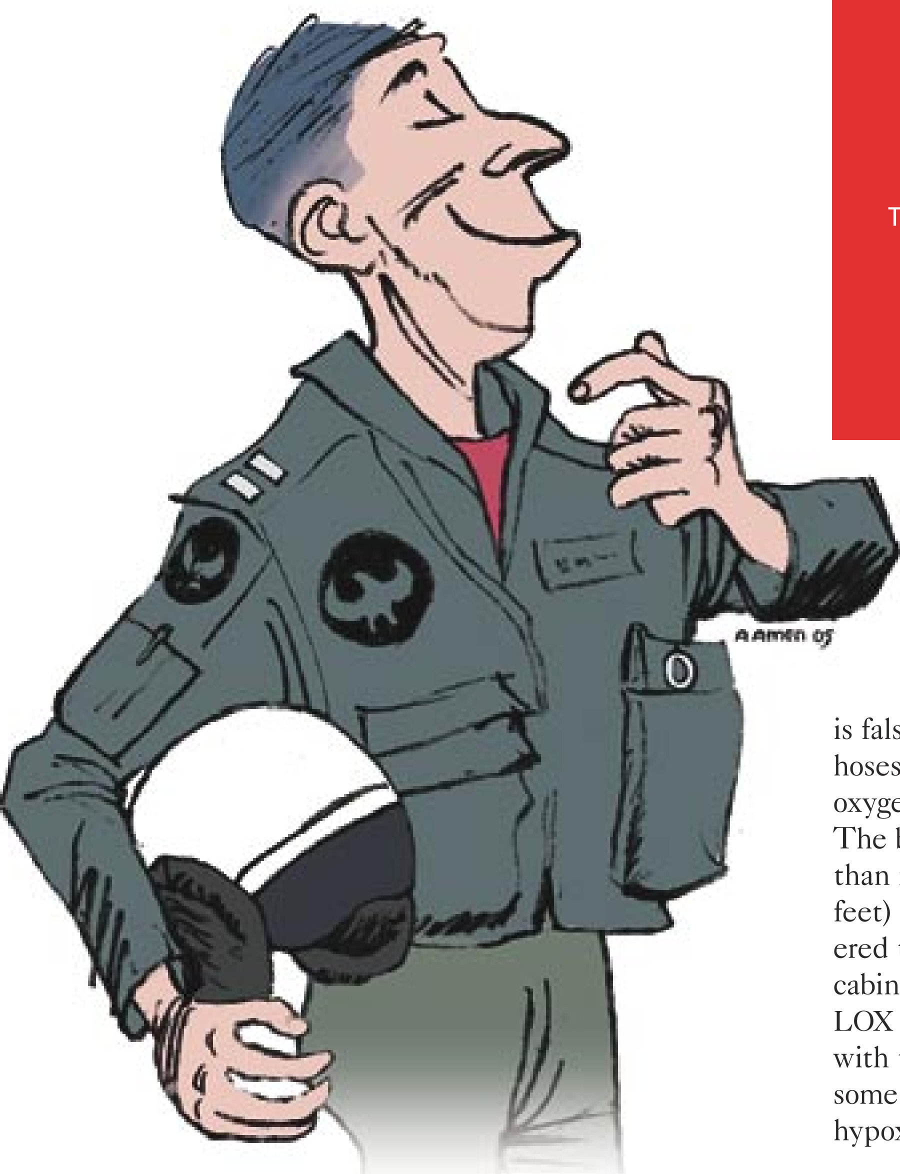
Do you consider yourself an expert on hypoxia? After all, you've been through your physiology training, and maybe even have tons of flight experience. You already know hypoxia means inadequate oxygen. But, hold on for a second. Maybe there's more to hypoxia than you think, and maybe even a few new wrinkles, too.

Let's check your hypoxia IQ—see how you do on this short quiz (don't worry, the quiz isn't graded). The first four are "True or False"

1. I can't get hypoxic with my mask on.
2. Hypoxia is caused by not breathing enough oxygen.
3. Hypoxia is not a problem below 10,000 feet.
4. I always wear my mask in accordance with NATOPS.
5. Define oxygen paradox.

The answers are

1. False
2. True, but…
3. False
4. True (it better be)
5. We'll get to oxygen paradox later.



How'd you do? I'm betting you didn't score 100 percent, even though the quiz addresses topics that are critical to every tactical-aviator's survival. Let's look at these questions a bit more closely.

Question 1 is straightforward. The statement is false because poorly fitted masks, holes in oxygen hoses, poor seals, and even forgetting to plug into the oxygen system can all lead to hypoxia with the mask on. The bottom line is that an aviator will get less oxygen than intended any time high-altitude (above 10,000 feet) cabin air mixes with the breathing mixture delivered to the mask. This situation rapidly worsens as your cabin altitude increases. A degraded or contaminated LOX or OBOGS system also could lead to hypoxia, even with the mask on, regardless of altitude. Read on for some physiologic conditions that can lead to mask-on hypoxia.

Question 2 is a trick question because the statement is only partly true. There actually are several causes or types of hypoxia. Here are four you should know:

Hypoxic hypoxia is the type we usually think of in aviation. This type occurs when there is *not enough oxygen in the air we're breathing,* as we see at altitudes above 10,000 feet. Aircraft have onboard oxygen and pressurization systems to prevent hypoxic hypoxia.

Hypemic hypoxia occurs in two major types. The first type is when there is *not enough blood* to carry adequate oxygen supplies to the body tissues. This situation can be caused by not having enough blood: anemia. Although anemia is more common among some female aviators, it also can be a problem for male aviators. Concern regarding anemia is the reason aviators cannot freely donate blood. The second type of hypemic hypoxia occurs when *something decreases the blood's ability to carry oxygen*. You probably are familiar with carbon monoxide, the most common cause of this form of anemia. Carbon monoxide prevents oxygen from entering the blood, causing less oxygen to be delivered to the body. Because carbon monoxide is a common combustion product, it is not unusual to have at least some exposure to it from sources such as engine exhaust or charcoal grills. However, tobacco smokers are chronically exposed to surprisingly high levels of carbon monoxide, and they cannot tolerate altitude as well as nonsmokers. The carbon monoxide absorbed from one pack of cigarettes can raise your effective physiologic altitude by 5,000 feet, or more. To put these facts into perspective, consider two aviators, one a smoker, the other a nonsmoker, both flying at a cabin altitude of 9,000 feet without supplemental oxygen. Because of the physiological effects of carbon monoxide, the smoker effectively will be at 14,000 feet or higher and is much more likely to experience hypoxic symptoms.

Stagnant hypoxia occurs when *blood flow is inadequate,* or there is blood pooling. For example, pulling high positive Gs can cause blood to pool in the legs and lower body. This condition leads to decreased blood flow to the brain, which becomes hypoxic, and the aviator may G-LOC. This phenomenon can occur at any altitude. The G-suit, M-1, L-1, hook maneuver, and anti-G straining maneuver (AGSM) are all aimed at preventing blood pooling and stagnant hypoxia.

Histotoxic hypoxia is a type of poisoning that *interferes with the body's ability to use oxygen*; cyanide poisoning is one well-known example. However, histotoxic hypoxia is not a common problem in aviation.

Question 3 is tricky, because we all know that the atmosphere below 10,000 feet has enough oxygen to support life. So if this is true, how can an aviator get hypoxic below 10,000 feet? Questions 1 and 2 provided several examples of situations where hypoxia can and does occur.

Question 4 should be a "gimme" because NATOPS is quite clear on this requirement. NATOPS requires all tactical aviators to use supplemental oxygen continuously from takeoff to landing. Aviators in other pressurized aircraft will use supplemental oxygen whenever the cabin altitude is above 10,000 feet. See OPNAVINST 3710.7T, paragraph 8.2.4, for details.

Question 5 addresses a phenomenon that may be unfamiliar to you. Oxygen paradox refers to the situation where a hypoxic aviator's symptoms get worse after he/she begins breathing supplemental oxygen. A real-life example will illustrate this phenomenon. An aviator flying at 25,000 feet without a mask on experiences mild hypoxic symptoms because of an unrecognized cabin-pressurization failure. When the aviator finally recognizes the hypoxic symptoms and dons the oxygen mask, he suddenly feels worse, becomes dizzy and is disoriented. The symptoms clear up after 15 seconds or so. What happened here? Why didn't the oxygen correct things right away?

One way to think about this is that while hypoxia shuts down the brain, supplemental oxygen will wake or reboot it again. The problem is the brain doesn't shut down or reboot all at once. Rather, it typically does so in a fairly predictable and organized pattern. Problems can occur when the brain reboots in a disorganized sequence. Fortunately, these problems generally are quick to correct, but the aviator may be unable to fly the aircraft until things sort themselves out. Unfortunately, a natural response is to think, "Hey, I got worse with the oxygen; it must be bad," and to remove the mask. But, that action is precisely the wrong thing to do, because it guarantees you will become more hypoxic. A far better solution would be to avoid hypoxia and oxygen paradox in the first place by wearing the mask as outlined in NATOPS. For a more physiologic perspective on oxygen paradox, check out Lt. Ostrander's article on page 13.

Whether you aced my quiz or not, I hope you have learned something that will make you a bit more hypoxia savvy, and a smarter, safer aviator, as well.

Cdr. Brooks is assigned to the Naval Safety Center.